WATER RESOURCES RESEARCH GRANT PROPOSAL

Title: Saline Water Investigations in Eastern Arkansas: Geochemical Tools to Characterize Sources of Saline Waters

Focus Categories: HYDGEO, WQ, GW

Descriptors: Ground-Water Quality, Saline-Freshwater Interfaces, Water Quality Management

Duration: March 1, 2000 –Feb. 28, 2001

Federal Funds:

Direct	$24,708
Indirect	$--0--
Total	$24,708

Non-Federal Funds:

Direct	$32,718
Indirect	$16,698
Total	$49,416

Principal Investigator’s Name(s) and Universit(ies)

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Congressional District of the University Where the Research is to be Conducted: Third

Statement of Critical State/Regional Water Problem

Saline groundwater underlies Arkansas at shallow depth. Lateral movement of saline water into fresh water by updip migration resulting from pumping was detected in areas of eastern and southern Arkansas (Newport, 1977; U.S. Geological Survey, 1984). Both the Alluvial Aquifer and the Sparta Aquifer have been impacted by saline intrusion (Morris and Bush, 1986; Broom et al., 1984). Critical ground water areas have been established in east-central Arkansas for the Alluvial and Sparta aquifers, and in southern Arkansas for the Sparta Aquifer as a result of declining water levels in these aquifers (Smith et al., 1999). There is also some saline water, especially in the shallower Alluvial Aquifer, that has resulted form oil and gas operations in the area, particularly in south-central Arkansas (Morris, 1988). Other potential sources of saline water include road de-icing, highway department storage piles, discharge from poultry and hog plants, and leaky landfills, among others (Richter and Kreitler, 1993). Saline water intrusion and near surface sources of saline water in eastern and south-central Arkansas is an increasing problem and will likely dominate our water quality concerns in Arkansas.

In southern Arkansas, the Sparta Aquifer is used as a primary drinking water source and the Alluvial Aquifer is used for irrigation purposes. Chloride concentrations in the Sparta Aquifer in Union County range from 25 to 150 mg/L. About 30% of the irrigation wells and relifts in Desha County have been reported to have chloride concentrations above 100 mg/L. (Broom et al., 1984; Morris, 1988). These high chloride concentrations can be detrimental to the use of the water. Saline water can decrease crop productivity, and cause corrosion and taste problems with drinking water. As saline water intrusion problems become more prevalent and impact more irrigation and drinking water supplies, the need will arise to be able to clearly differentiate the various sources of contamination. Defining the spatial distribution of saline water in the Alluvial and Sparta aquifers in relation to significant areas of ground-water level decline is a critical need. In addition, Geochemical fingerprinting is a tool that may prove to be beneficial to help differentiate sources of saline water contamination to these aquifers.

Statement of Results or Benefits:

Dealing with more than one potential source of saline contamination is not uncommon. Being able to quickly identify contributions from various sources allows the development of management strategies that are targeted at the dominant source within a given area. Intrusion of saline water as a result of aquifer dewatering requires a different management approach than contamination that may be associated with leakage from drilling pits, leaky piping, tank overflows, malfunctioning Class II disposal wells, or other near surface sources. Therefore, the primary benefits of this project will be to define the spatial distribution of saline waters relative to known areas of ground-water level decline in the Alluvial and Sparta aquifers, and identification of the most probable source of saline water contamination for selected sites in the Alluvial and Sparta aquifers in eastern and southern Arkansas, if possible. This effort will be coordinated with current state funded research to define the spatial extent of areas of saline water in eastern Arkansas. If geochemical fingerprinting is successful, these data will allow groundwater planners and managers to develop and implement management strategies and programs that are targeted to the most probable source of contamination helping to reduce the cost of management and the cost to the regulated community.

Nature, scope, and objectives of the research:

The goals of this project are 1) define the spatial distribution of saline water relative to significant areas of ground-water level decline in the Alluvial and Sparta aquifers in eastern and southern Arkansas, and 2) geochemical identification of sources of saline groundwater contamination in selected areas of eastern and southern Arkansas that are experiencing significant ground-water level declines, if possible. Saline groundwater underlies Arkansas at shallow depth. Lateral movement of saline water into fresh water by updip migration resulting from pumping was detected in areas of eastern and southern Arkansas (Newport, 1977; U.S. Geological Survey, 1984). Both the Alluvial Aquifer and the Sparta Aquifer have been impacted by saline intrusion (Morris and Bush, 1986; Broom et al., 1984). Critical ground water areas have been established in east-central Arkansas for the Alluvial and Sparta aquifers, and in southern Arkansas for the Sparta Aquifer as a result of declining water levels in these aquifers (Smith et al., 1999). There is also some saline water, especially in the shallower Alluvial Aquifer, that has resulted from oil and gas operations in the area, particularly in south-central Arkansas (Morris, 1988). Other potential sources of saline water include road de-icing, highway department storage piles, discharge from poultry and hog plants, and leaky landfills, among others (Richter and Kreitler, 1993). Saline water intrusion and near surface sources of saline water in eastern and south-central Arkansas is an increasing problem and will likely dominate our water quality concerns in Arkansas. The U.S. Geological Survey (USGS) has provided data to the Arkansas Soil and Water Conservation Commission regarding specific conductance levels in groundwater. These data have been collected as part of the USGS aquifer-sampling program (Earl et al., 1999). The specific conductance data provide an indication of areas of higher salinity and provide a mechanism to track water quality changes over time resulting from salinity. However, specific conductance does not provide an indication of the source or sources of increasing salinity within the aquifers of eastern and southern Arkansas. Saline water from different sources contain ions that are specific to that source. Identification and comparison of ion ratios for water from different sources provides a mechanism of geochemical fingerprinting of the water (Novack and Eckstein, 1988; Dutton et al., 1989; Huff and Hanor, 1997; Knuth et al., 1990; Whittemore, 1984). Based on the ion ratios, mixing curves can be generated to ascribe the percentage contribution of the salinity to the various potential saline sources within the contributing area.

The objectives of this project are:

a) Select an area in the Alluvial Aquifer and an area in the Sparta Aquifer that have been identified as areas of high chloride or high specific conductance.

b) Coordinate this research effort with current state funded project to collect and analyze samples from the same vicinity and map the spatial distribution of chloride concentrations in eastern and southern Arkansas relative to areas of significant ground-water level decline.

c) Coordinate this research effort with ongoing data collection efforts being conducted by state and federal agencies including the U.S. Geological Survey, Arkansas Department of Environmental Quality, and Arkansas Soil and Water Conservation Commission.

d) Collect 25 groundwater samples from each of the areas, which will be analyzed for major inorganic constituents and selected trace elements that can be used to determine the source of the saline water.

e) Delineate the magnitude of chloride concentrations within each of these selected areas (spatial distribution of concentrations).

f) Delineate the spatial distribution of sources of salinity within each of the selected areas.

Methods, Procedures, and Facilities:
Site selection within the Alluvial and Sparta aquifers will be based on areas of greatest groundwater level declines. In addition, within these defined areas the region will be narrowed to target the areas with the highest concentrations of chloride, specific conductance, and/or total dissolved solids. This site selection process will be based on a review of existing publications and data sets. This process will occur in the period from March 1, 2000 to May 15, 2000. The second stage will be acquiring permissions to sample the wells. This will require direct contact with the well owners. This process will occur in the period from April 15, 2000 to June 15, 2000.

Water samples will be collected from irrigation, municipal and/or industrial wells producing water from the targeted formations. High capacity wells are selected for this project rather than domestic wells because we want wells that are creating significant drawdown within the aquifer. It is these wells that will have the greatest potential to create updip migration of saline formation waters.

Water sampling will occur during the peak of the irrigation season (June 2000 to August 2000) to insure maximum stress on the aquifer at the time of sampling. This will also coincide with peak municipal usage as a result of summer time lawn watering and swimming pool use.

Twenty-five samples will be collected from the Alluvial Aquifer and from the Sparta Aquifer for a total of 50 samples. At least five duplicate samples will be collected as part of the Quality Assurance/Quality Control protocol for this project. In addition, at the time of sample collection the pH, water temperature, alkalinity, and specific conductance will be measured. The samples will be appropriately preserved, cooled and transported to the Arkansas Water Resources Center Water Quality Laboratory at the University of Arkansas-Fayetteville where they will be analyzed for selected major inorganic constituents and selected trace elements such as Na, K, SO_4, Cl, HCO_3, Ca, Mg, Li, Br, and I.

Available hydrogeological information will be obtained for each well sampled. This may include a geological log, pump test data, water level data and/or existing water quality analyses. The geologic data are critical to proper interpretation of the data.

Data analysis will be by graphical and statistical techniques. Richter and Kreitler (1993) provide a relatively comprehensive discussion of both graphical and statistical techniques of data analysis that can be utilized to analyze the water quality data and aid in identification of sources of groundwater salinization. Graphical techniques are used to illustrate the chemical character of a single analysis, compare the characteristics of several analyses, assist in identifying the relationship that exists between water samples, and/or to calculate mixing rations between fresh water and the contaminating source (Richter and Kreitler, 1993). These techniques include mapping the spatial distribution of the contaminant plumes both horizontally and vertically, bar graphs, pie charts, Stiff diagrams, Schoeller diagrams, and trilinear diagrams. Bivariate plots are useful for identification of mixing curves. Stepwise Discriminant Analysis has been successfully used to identify variables that distinguish between two or more predetermined groups (Richter and Kreitler, 1993). However, this requires a very large data set. Our data set may not be large enough to employ this statistical technique.

The spatial distribution of chloride concentrations and the identified geochemical fingerprints for the water will be presented in an ArcView format. If sufficient data are available the vertical distribution will also be presented for each of the aquifers.

Related Research:

Sources of saline water have been previously defined within selected areas of Arkansas. Morris and Bush (1986) defined the extent and source of saltwater in the Alluvial Aquifer near Brinkley, Arkansas. Fitzpatrick (1985) prepared a map of the distribution of saltwater in the Boef Tensas basin. Bryant et al. (1985) discussed the occurrence of areas of significant saline water problems within Arkansas. Broom et al. (1984) investigated saltwater contamination within the Sparta Aquifer in the vicinity of El Dorado, Arkansas. Currently, the main emphasis is on collection of specific conductance data and chloride data from selected wells that fall under the USGS groundwater a sampling program (Earl et al., 1999). To date, only limited water quality analysis and/or data interpretation related to geochemical fingerprinting of the sources of saline contamination has occurred in Arkansas.

Richter and Krietler (1993) have compiled information from a large body of literature into a review paper on geochemical techniques for identifying sources of ground-water salinization. This comprehensive review provides excellent information on the status of work within affected areas throughout the United States as well as a review of necessary chemical analysis and data interpretation methods to adequately geochemically fingerprint the various saline contaminant sources. Huff and Hanor (1997) utilized Sr isotopic composition to identify sources of saline contamination in the Wilcox group in east-central Louisiana. Dutton et al. (1989) used oxygen isotopic composition of the water in conjunction with major inorganic chemistry and selected trace element analysis to characterize brines in the Concho River watershed , West Texas. Novak and Eckstien (1988), Knuth (1990) and Whittemore (1984 and 1988) have used similar techniques to characterize brines and provide source identification and mixing curves for areas in eastern Ohio and south-central Kansas.

The source identification and mixing curves provided by Whittemore (1984 and 1988) have been incorporated into models of groundwater flow and saltwater upconing, and a decision support model to assess the vulnerability of additional aquifer contamination in the area of south-central Kansas (Sophocleous and Ma, 1998; Ma et al., 1997). This is the next logical step for our project after the sources of contamination and the mixing curves have been developed for the Alluvial and Sparta aquifers in Arkansas.

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